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PATENT APPLICATION

of

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for a

PORTABLE MULTIMODE DISPLAY DEVICE

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PORTABLE MULTIMODE DISPLAY DEVICE

Field of the Invention

The present invention relates generally to a portable device and, more specifically, to a portable device having a high-resolution display for viewing still and video images and having multi-media capability.

Background of the Invention

People that have a portable lifestyle would appreciate instant access to a large amount of information via a portable device, such as a mobile phone, personal data assistant, communicator and the like. While it is a common practice to use a low-resolution liquid-crystal display (LCD) panel to display network information and text messages, it is preferred to use a high-resolution display to browse rich information content of text and images. The high-resolution displays typically have at least SVGA (800x600 pixels) resolution and are of an active matrix type. They can be used for direct view displays or virtual displays. The virtual displays are known as Near Eye Displays (NED). Direct view displays can be visible simultaneously to several observers, whereas the virtual display is only for one person. Virtual displays consist typically of a microdisplay and imaging optics. They can be monocular or binocular. The perceived image in a virtual display can be larger than the device itself. The usability of the virtual display depends very much on the performance of the microdisplay and optics.

The size of the beam of light emerging from imaging optics towards the eye is called exit pupil. In NED, it is typically of the order of 10 mm in diameter. The ease of the use of a virtual display would be improved significantly if the exit pupil were enlarged. When the exit pupil is large enough, the device can be at a distance from the eye, and the display would not then be NED, but would still be a virtual display. In this context, this operating mode is called Window-mode.

The pixel pitch, which is resolvable to the human eye, determines the necessary size of a high-resolution direct view display. This means, in practice, that the size of the display would be larger than the small portable device itself. In addition to virtual display, projection of an image also provides a method to overcome this dilemma. However, the

power consumption of the illumination would be too high for a battery operated portable device, even if the projected image is only about 10 inches in diagonal. It is advantageous and desirable to provide a method that can show high-resolution images in reasonable size. In battery-operated devices, the window or projection mode is desirable. The power consumption in window mode is slightly larger than in NED mode, but is reasonable for a battery operation. The power consumption in projection mode depends on the size of the projected image. Thus, in battery operation the projected image size would be limited. If the projected image is the size of a typical computer monitor or larger, a connection to an external light source is necessary.

Summary of the Invention

The primary objective of the present invention is to use a portable device having a display system, which can work in several display modes, using a microdisplay as an image source and enlarging the image by different optical arrangements corresponding to different display modes.

The first mode of operation is a virtual Near Eye Display (NED), which typically uses a microdisplay as an image source and an imaging optical arrangement to deliver the image to the eye of a viewer.

The second mode is a Near Projection Display (NPD), which uses a near field projection optical arrangement to provide a projected image on a screen at a near distance of 5 – 25 cm, for example.

The third mode is a Window Mode Display (WMD), where the image appears through a special optical element, which enlarges the exit pupil of the imaging optical arrangement so that the image appearing on the microdisplay is provided as a virtual image to a viewer at a distance.

The fourth mode is Projection Display (PD), whereby the image is projected onto a screen, at a distance of 0.5m - 2.5m from the device, and the real image appears to be up to 1 m in diagonal, for example.

According to the present invention, an optical engine is used to form an image based on the optical arrangements of each mode of operation of the device. The optical engine consists of an image source, such as a microdisplay device, a light source, one or

more lenses for collecting light from the light source for illuminating the image source, other optical elements and one or more lenses which form the imaging optics. A number of different lens arrangements are used to achieve the desired display modes. The internal light source, powered by one or more batteries in the portable device, is used for illumination in the first three modes. For projecting an image at a screen disposed at a distance from the portable device, however, an external light source may be needed. Preferably, the illuminating light from the external light source is brought to the portable device via an optical light guide.

Accordingly, the present invention provides a portable device having a plurality of selectable display modes for providing an image to a viewer, the portable device comprising:

an image source;

an illuminating light source for providing illuminating light to the image source for providing output light from the image source;

a first optical arrangement for forming the image from the output light along an optical path of the first optical arrangement; and

a second optical arrangement, disposed in the optical path, for modifying the image forming of the first optical arrangement.

According to the present invention, the selectable display modes include:

a first mode for allowing the viewer to perceive the image by placing an eye in the optical path adjacent to the portable device;

a second mode for allowing the viewer to perceive the image formed on a surface disposed in the optical path adjacent to the portable device;

a third mode for allowing the viewer to perceive the image by placing the eye in the optical path at a distance from the portable device; and

a fourth mode for allowing the viewer to perceive the image formed on a surface disposed in the optical path at a distance to the portable device.

The present invention will become apparent upon reading the description taken in conjunction with Figures 1 to 7.

Brief Description of the Drawings

Figure 1 is a block diagram showing some of the basic components in a portable device, according to the present invention.

Figure 2a is a diagrammatic representation showing an optical engine having a reflective-type microdisplay.

Figure 2b is a diagrammatic representation showing an optical engine having a transmissive-type microdisplay.

Figure 2c is a diagrammatic representation showing the optical engine having an emissive-type microdisplay.

Figure 3 is a diagrammatic representation showing the optical engine being used to provide a virtual image at a NED configuration.

Figure 4 is a diagrammatic representation showing the optical engine being used to provide a real image on a screen at a near distance via a reflector.

Figure 5 is a diagrammatic representation showing the optical engine being used to provide a virtual image to be observed at a distance from the portable device.

Figure 6 is a diagrammatic representation showing the optical engine being used to provide a real image on a screen positioned at a distance from the portable device.

Figure 7 is a diagrammatic representation showing an external light source.

Best Mode for Carrying Out the Present Invention

The portable device **1**, according to the present invention, uses an optical engine **16** and different optical arrangements to provide an image to a viewer in different display modes. The portable device **1** can be a mobile phone, a personal digital assistant (PDA), , a communicator and other portable electronic devices. Preferably, the portable device **1** has a housing **10** to house a communication unit **12** for receiving and transmitting information from and to an external device, a controlling and processing unit **14** for handling the received or transmitted information. More particularly, the controlling and processing unit **14** is operatively connected to the optical engine **16** for providing image data to the microdisplay device **32, 32'** or **32"** to display an image thereon (see Figures 2a to 2c). In addition, the portable device **1** comprises an internal light source **20** for providing illuminating light to the optical engine **16**, if necessary, and an internal power

source **22** for providing power to the internal light source **20**. The internal power source **22** may contain one or more batteries. Moreover, when the optical engine **16** is used for projecting a real image at a distance screen, it may be necessary to bring in a light beam from an external light source. Thus, it is preferable to have a connector **24** for connecting one end of a light guide **70** to the portable device **1** (Figures 6 and 7). In order to select the display modes, it is preferable to have a device **18** to select different optical arrangements for different display modes.

The optical engine **16**, according to the present invention, may comprise a reflective-type microdisplay **32**, a transmissive-type display **32'**, or an emissive-type display **32"** as an image source. As shown in Figure 2a, one or more lenses **30** are used to collect light **100** from the internal light source **20**, or the light beam **100'** brought in by the light guide **70**, and expand the collected light into a broad beam **102** for illuminating the microdisplay **32**. One or more lenses **36** are used to collect output light from the microdisplay device **32** for forming an image. As shown in Figure 2a, a beam-splitter **34** is used to fold the optical path of the illuminating beam **102**. More particularly, the beam splitter **34** is a polarizing beam-splitter (PBS) and the reflected light beam **102** is s-polarized. With such an arrangement, the light beam **104** that provides an image to a viewer is p-polarized.

When a transmissive-type microdisplay device **32'** is used as an image source, as shown in Figure 2b, it is possible to dispose the microdisplay device **32'** between the illuminating optics **30** and the imaging optics **36** without folding the optical path of the expanded beam **102**. Preferably, polarizers **40**, **42** of different polarization axes are used to provide light beams with orthogonal polarization.

When an emissive-type microdisplay device **32"** is used as an image source, as shown in Figure 2c, no illuminating optics nor light source is needed. With an emissive-type microdisplay device **32"**, the optical engine **16** may not have sufficient light for projecting a real image at a distance screen.

It is understood that the image-forming beam **104** is propagated along an optical path **130** defined by the imaging optics **36**. In order to view the image displayed on the microdisplay device **32, 32', 32"**, one must place an eye or an object in the optical path **130**. The imaging optics **36**, in the simplest case, is just a magnifying lens. In more

complex cases, there might be several optical elements. In order that the imaging optics **36** in the optical engine **16** can be rearranged or reconfigured to form an image according to the mode of operation of the device **1**, it is preferred that the imaging optics **36** comprise a plurality of lenses and other optical components.

The optical engine **16** is designed in such a way that, in the NED configuration, a viewer **150** can directly view the image formed by the imaging optics **36** by placing an eye in the optical path **130** adjacent to the portable device **1**, as shown in Figure 3. In this NED mode, the image provided by the optical engine **16** is a virtual image. The size of the perceived image can be slightly or significantly larger than the microdisplay device **32** itself. In the NED mode, the power consumption is low. Thus, it is possible to use the internal light source **20** for illumination. The internal light source **20** may comprise one or more light-emitting diodes powered by one or two batteries in the portable device **1**, for example, but it is also possible to use a different type of lighting device.

Figure 4 shows an optical arrangement for the near projection display (NPD) mode. When the portable device **1** is used in the NPD mode, the imaging optics **36** are rearranged or reconfigured to form a real image on a surface or screen **60**. A reflecting surface **62**, such as a first surface mirror, is used to fold the optical path of the image-forming beam **106.** Preferably, the projected image is in the order of 10 cm in diagonal and the screen is an integral part of the device. Although the power consumption in the NPD mode is expected to be much higher than that in the NED mode, it is still possible to use the internal light source **20** for illumination. Preferably, the screen **60** has such characteristics that the image can be viewed within a reasonably large viewing angle. The system can be used without a folding mirror or, alternatively, several mirrors can be used to fold the image-forming beam **106** in order to minimize the size of the device. It is possible that additional lenses and other optical components are disposed between the optical engine **16** and the screen **60** to reconfigure the NED optics.

In the third display mode (WMD), additional optical components are used to extend the exit pupil of the imaging optics **36** in the optical engine **16** so that the virtual image formed by the imaging optics **36** can be viewed at a greater distance from the device. As shown in Figure 5, outgoing light **120** from an exit pupil extender **54** will form a virtual image at a distance from the device **1**. The virtual image, as perceived by a

viewer in this WMD mode, can be larger than the physical size of the extender **54** itself because the image appears at a distance. The power consumption of this mode is slightly higher than that of the NED mode, but lower than that of the NPD mode. It is possible to use the internal light source **20** for illumination.

The fourth display mode of the portable device **1**, according to the present invention, is illustrated in Figure 6. When the device is used in the fourth display mode, the imaging optics **36** are rearranged or reconfigured to project the real image by an image-forming beam **108** to a larger screen **64** at a larger distance. In this display mode, it is required that an external light source is used to provide an intense light beam to illuminate the microdisplay **32, 32'**. To achieve this display mode, it is preferable to use a light guide **70** to convey an illuminating light beam from an external light source **80** (Figure 7) to the portable device **1** through the connector **24**. It is possible to use additional lenses and other optical components disposed between the optical engine **16** and the screen **64** to reconfigure the NED optics.

The light source for projection is typically a discharge lamp, such as an Ultra High Pressure (UHP) Mercury lamp. The efficiency of such a lamp is typically only about 10%, and the rest of the power is converted to heat. Quite a significant part of the heat is Infra Red (IR) radiation, which can overheat the microdisplay and cause severe damage to the portable device itself, or even destroy it within a short time. This problem is compounded by the fact that there would not be sufficient space in the portable device to include an effective cooling system to dissipate the heat associated with the light source. Thus, an external light source **80**, such as the one shown in Figure 7, must be used, instead of the internal light source **20**.

As shown in Figure 7, a lamp **84** with a reflector is used as a light source. The lamp **84** is powered by a power supply **82**. The light output from the lamp is filtered by an IR/UV filter **86** and focused into the light guide **70**. Preferably, a light sequencer **88** is provided in the light path to turn the light beam to the light guide **70** into sequential colors under the control of the portable device **1**. As shown in Figure 7, an electrical cable **72** connecting the portable device **1** to the external light source **80** allows the portable device **1** to send a control signal to the light sequencer **88** according to the selected display mode.

In summary, the portable device, according to the present invention, includes an optical engine, which is adapted to form an image according to one or more display modes. The portable device is designed such that the change between different display modes can be easily carried out.

Although the invention has been described with respect to a preferred embodiment thereof, it will be understood by those skilled in the art that the foregoing and various other changes, omissions and deviations in the form and detail thereof may be made without departing from the spirit and scope of this invention.